MISCIBLE RECOVERY

Techniques for gas miscible recovery include carbon dioxide flooding, cyclic carbon dioxide stimulation, nitrogen flooding and nitrogen-CO_2 flooding.

Carbon dioxide flooding is commonly used to recover oil from reservoirs in which the initial pressure has been depleted through primary production and possibly waterflooding. Water is injected into the reservoir until pressure is restored to a desired level, then CO_2 is introduced into the reservoir through these same injection wells. As the CO_2 is forced into the reservoir a zone of miscible CO_2 and light hydrocarbons forms a front that is soluble with the oil, making it easier to move toward production wells. The initial CO_2 slug is typically followed by alternate water and CO_2 injection - the water serving to improve sweep efficiency and to minimize the amount of CO_2 required for the flood. Production is from an oil bank that forms ahead of the miscible front. As reservoir fluids are produced through production wells, the CO_2 reverts to a gaseous state and provides a "gas lift" similar to that of original reservoir natural gas pressure.

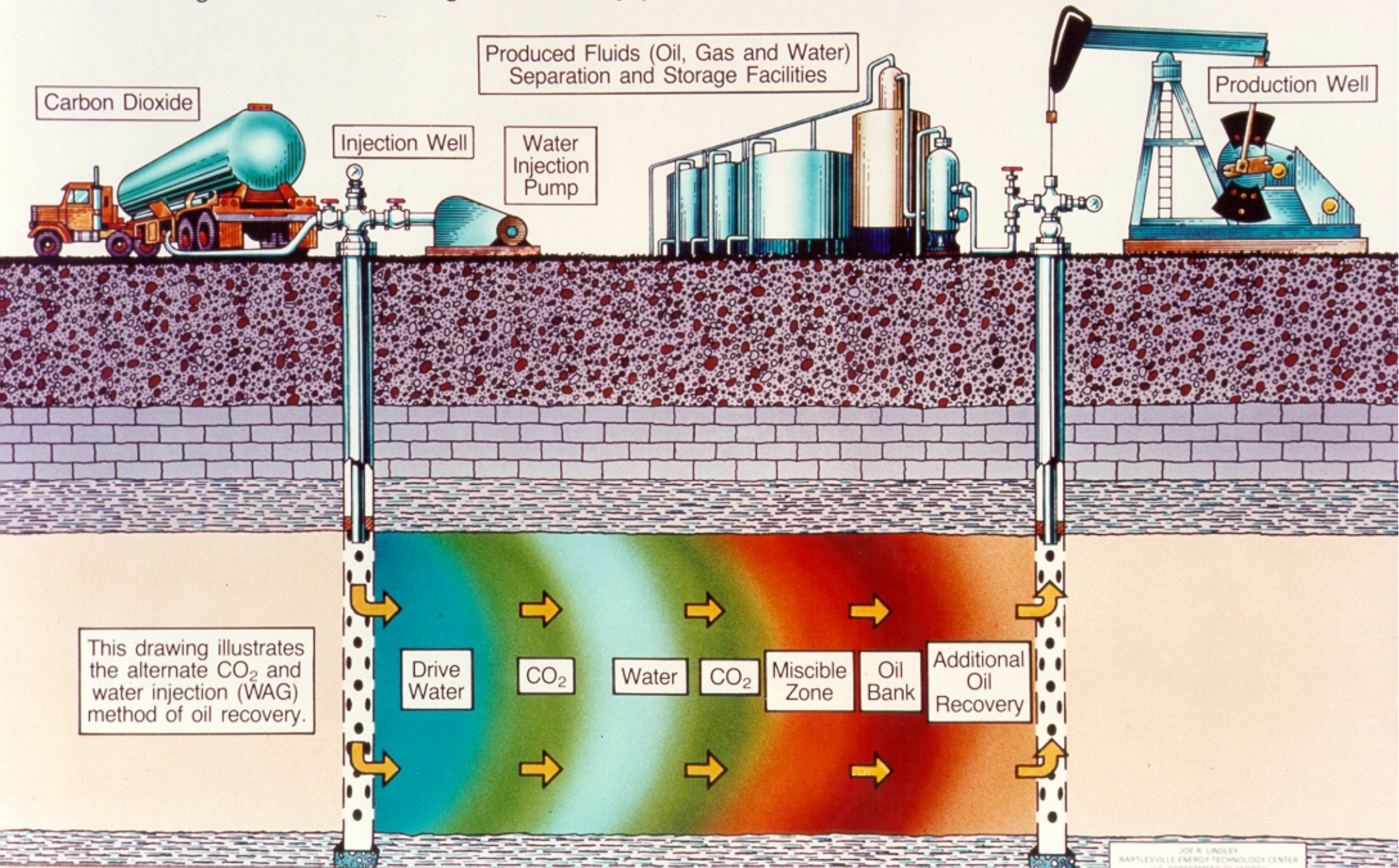
Cyclic carbon dioxide stimulation, also known as the “huff-and-puff” method, is a single-well operation, which is developing as a method of rapidly producing oil. Similar to the cyclic steam process, CO_2 is injected into an oil reservoir, the well is shut in for a time, providing
for a "soak period," then is opened, allowing the oil and fluids to be produced. The dissolving of the CO_2 in the oil reduces the oil’s viscosity and causes it to swell, allowing the oil to flow more easily toward the well. The process can also be used in heavy oil reservoirs by high-pressure injection of CO_2 to facilitate miscibility between the oil and CO_2, and in cases where thermal methods are not feasible.

Nitrogen flooding can be used to recover "light oils" that are capable of absorbing added gas under reservoir conditions, are low in methane, and at least 5,000 feet deep to withstand the high injection pressure necessary for the oil to mix with the nitrogen without fracturing the producing formation. When nitrogen is injected into a reservoir, it forms a miscible front by vaporizing lighter oil components. As the front moves away from the injection wells its leading edge goes into solution, or becomes miscible, with the reservoir oil. Continued injection moves the bank of displaced oil toward production wells. Water slugs are injected alternately with the nitrogen to increase the sweep efficiency and oil recovery. Nitrogen can be manufactured on site at relatively low cost by extraction from air by cryogenic separation, and being totally inert it is noncorrosive.

In *nitrogen - CO_2 flooding*, because of its lower cost, the nitrogen can be used in a CO_2 flood to displace the CO_2 slug and its oil bank.

MISCIBLE RECOVERY

Recovery methods in this category include both hydrocarbon and non-hydrocarbon miscible flooding. These methods involve the injection of gases (carbon dioxide, nitrogen, flue gases, etc.) that either are or become miscible (mixable) with oil under reservoir conditions. This reaction lowers the resistance of oil to flow through a reservoir, making it more easily produced, either by water drive or injected gas pressure.



This drawing illustrates the alternate CO_2 and water injection (WAG) method of oil recovery.